FERMILAB

325 MHz Cavity Test Cryostat
2 K Conversion
Functional Requirements Specification

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Revision History

Revision	Date	Section No.	Revision Description
0.0	11-OCT-2010	All	Initial Release

INTRODUCTION

The 325 MHz cavity test cryostat is a facility located in the Meson Detector Building (MDB) for testing dressed 325 MHz spoke resonators. The purpose of these tests is to measure the performance of the cavity, tuners, and input coupler prior to installation into a longer multi-cavity cryomodule. The test cryostat was completed in 2009 and installed at MDB late that same year. The move to MDB was completed in late 2009 and the first cold test of a single spoke resonator was completed in September 2010. In its initial and current configuration the cryostat is capable of cooling down and operating a single dressed cavity nominally to 4.5 K. The scope of this project is to retrofit the facility to enable operation of all single spoke resonators envisioned for Project X at temperatures down to 2 K in CW mode. The design utilizes many of the features found in the current 1.3 GHz horizontal test facility in the cave adjacent to the 325 MHz cavity test cryostat. The current installation is shown in Figure 1.

Figure 1. Current 325 MHz Test Cryostat Installation in MDB

SCOPE OF WORK

The following are the major tasks required to complete the conversion.

1. Design and fabricate a new “top hat” and internal piping assemblies.
2. Design and fabricate three new transfer lines to connect to the existing bayonet can.
3. Modify the piping external to the cryostat to facilitate the new operation. This work primarily involves the pumping line for 2 K operation and the pressure relief circuit.
4. Modify the cryogenic control system to include the 2 K pumping circuit and added instrumentation.
5. Complete new piping and system engineering notes.
6. Test and commission.

INTERFACES

The existing 325 MHz cavity test cryostat has interfaces to the MDB cryogenic system, laboratory data acquisition systems, and the MDB 325 MHz RF systems. This will continue to be the case after the 2 K conversion is complete. It is assumed these systems are in place and operational to realize the full potential of this facility. The major interface will be to the MDB cryogenic system to support this and other superconducting testing facilities at MDB. However, the potential exists for these mostly independent operations to impact one another.

REQUIREMENTS

Operational Requirements

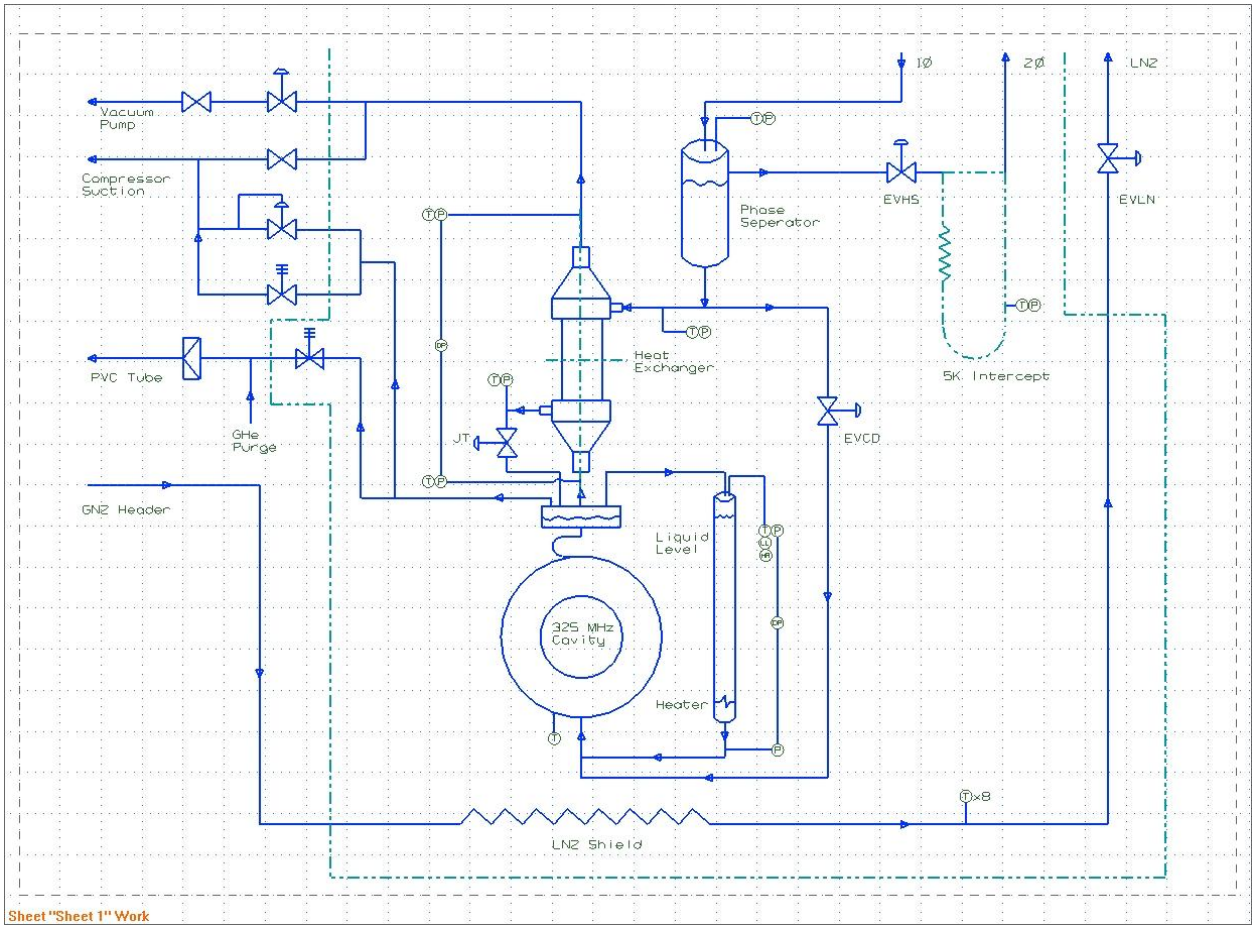
The test facility should accommodate the following tests at a minimum.

1. Q vs. E for fast and slow cooldown, especially between 150 K and 70 K.
2. Cavity magnetic field sensitivity – repeatedly quench cavity in the presence of a magnetic field to determine effect on Q vs. E.
3. Cavity magnetic field sensitivity – expose cavity to small magnetic field during cooldown below 10 K to determine effect on Q vs. E.
4. Measure pressure fluctuations at 2 K and 4.5 K and determine cavity frequency sensitivity.
5. Measure f vs. E^2 to obtain Lorentz force detuning coefficient.
6. Full range of slow and fast tuner tests including microphonics compensation.
7. Maintain the potential for testing a cavity and solenoid combination although the present and planned configurations of the cryostat do not include current leads for magnets. Magnet testing at 2 K would likely require significant alterations to the cryostat to accommodate the conduction cooled current leads presently in development.

Technical Requirements

The following are general requirements of the overall installation.

1. Support cavity and/or magnet testing to ~2 K with a total heat load up to 30 W. Input power shall be controllable, e.g. by manual modulation to limit total heat generation to 30 W.
2. The facility will incorporate three separate vacuum systems for the insulating vacuum, cavity vacuum, and warm coupler vacuum.
3. Cooldown from room temperature to operating temperature should be completed in 24 hours or less. Warmup to room temperature should also be completed in 24 hours or less.
4. Operation must be possible at nominal temperatures of 4.5 K and 2 K.
5. Pressure stability at 2 K should be better than +/- 0.1 mbar.
6. During cooldown, the transition from 150 K to 70 K should be made in 1 hour to minimize the effects of Q-disease.
7. Every effort should be made to keep the static heat load to 2 K to a minimum.
8. A magnetic shield, integral to the cryostat shall attenuate the Earth's field at the cavity position ≤10 milligauss.
9. Flexible transfer lines should be permanently connected to the cryostat and utilize Fermilab-style bayonets at the bayonet can end.
10. Instrumentation to monitor the insulating vacuum pressure shall be available.
11. Instrumentation must be available to measure head load to 2 K and to fully monitor cryogenic operation.
12. Instrumentation will include, but not be limited to, the following
    a. Cavity vacuum, insulating vacuum, and input coupler vacuum indication.
    b. Helium bath pressure, temperature, and liquid level.
    c. A heater to facilitate calorimetry measurements.
    d. Input coupler temperature.
    e. Thermal shield temperature.
    f. Diode x-ray detectors.
    g. Capability to power coils for magnetic field tests up to 16 A.
    h. Coil temperature.
    i. Cavity field probe.
    j. Coupler e-probes.
    k. Tuner control and diagnostics.
    l. Helium vessel outside temperature (4 cernox, 2 platinum).
13. Testing all spoke cavity types, i.e. SSR0, SSR1, and SSR2.
14. Nitrogen purge line to inside of cryostat.



Safety Requirements

1. All existing safety procedures relating to the original test cryostat installation will remain in place.
2. All existing training requirements relating to the original test cryostat installation will remain in place.
3. All existing interlock procedures relating to the original test cryostat installation will remain in place.
4. A piping engineering note will be written, reviewed, and approved prior to operation as outlined in Fermilab ES&H Manual chapter 5031.1. The completed piping system will be pressure tested and documented as outlined in Fermilab ES&H Manual chapter 5034. The original existing vacuum vessel engineering note will be modified to incorporate any changes resulting from the new top hat assembly.

Test and Commissioning Requirements

When the 2 K conversion is completed, the installation will be commissioned by cooling down a dummy load and measuring the static heat load to 2 K. Integrated commissioning of the cryogenic and RF systems will be carried out using a dressed spoke cavity and running through the full suite of cavity tests. Successful completion of that series of tests shall fulfill the system commissioning requirements.